To: N.Holtkamp,R.Kustom,J.Wei,J.Galambos,K.Reece,G.Dodson,S.McKenzie,J.Johnson, F.Gallmeier

From: E.Tanke

Subject: Possible radiation due to rf dark current in the DTL

Recently, Roy Cutler made me attentive to the high levels of rf induced radiation, which have been measured at the FNAL DTL [1]. Figure 1 shows that there is no apparent correlation between the measured radiation levels and rf parameters such as peak surface fields or (largest) gap voltage.

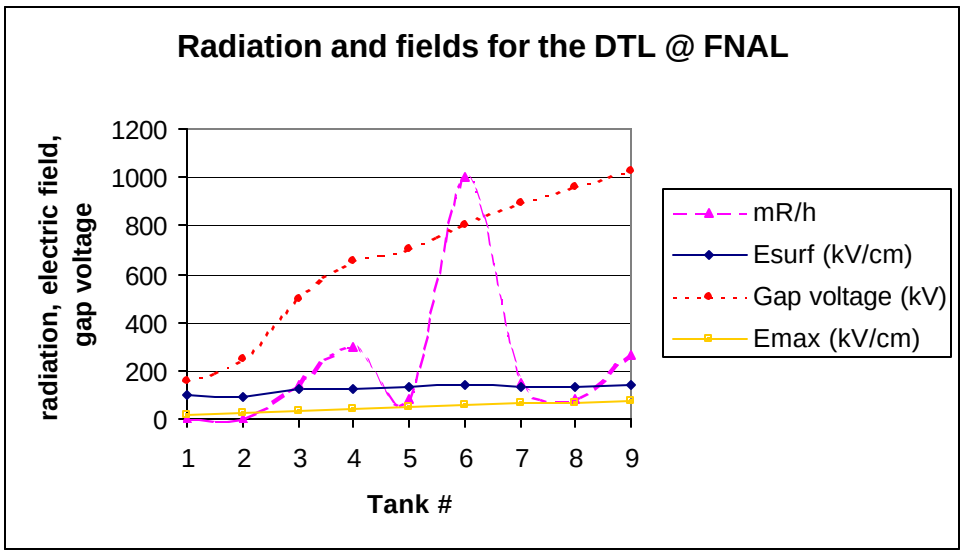

Figure 1: Measured radiation at the FNAL DTL.

One possible cause for dark current is multipactor. Above a certain maximum field Emax, however, multipacting cannot occur [2]. From figure 1 it can be seen that the peak surface fields in the FNAL DTL are well above this Emax. Nevertheless, in localized places surface field strengths may well be just under Emax and for pulsed operation the multipactor limit would be passed twice per pulse.

Another source for dark current can be electron field emission. Figure 2 shows the calculated field emission and radiation for the FNAL DTL, using a $\beta = 200$ as field enhancement factor in the Fowler-Nordheim law [3], as compared to the measured radiation level. From it one can see that within a factor 3 (above or below) the calculated radiation fits the measured one.

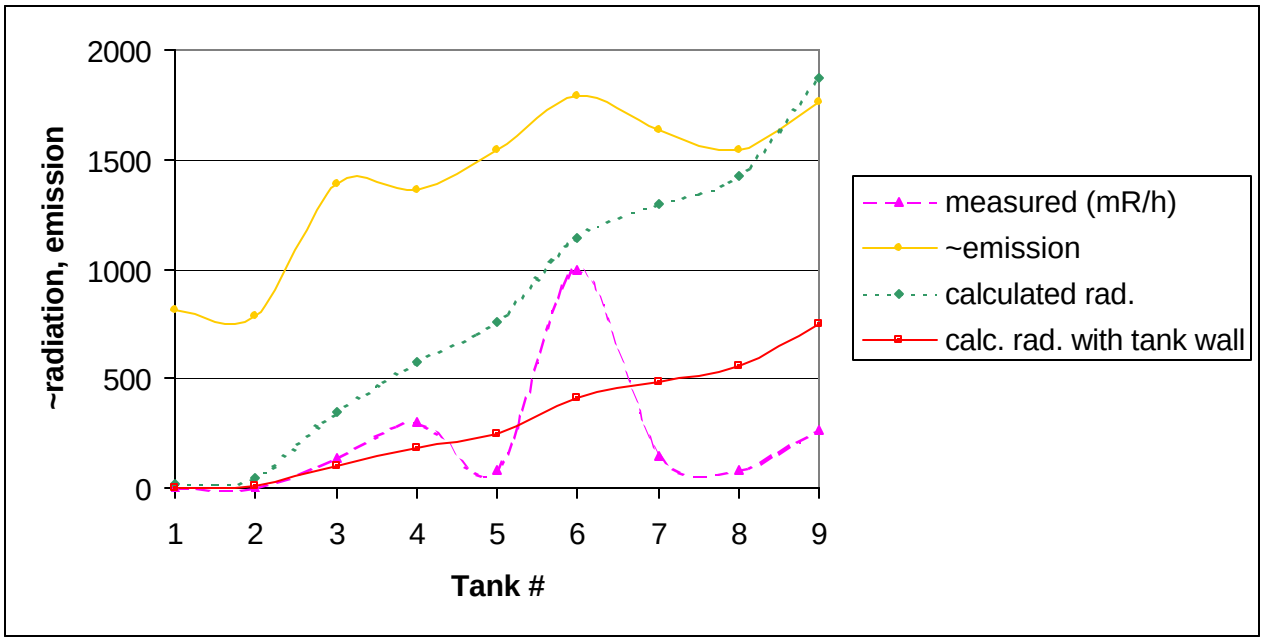

Figure 2: Measured and calculated radiation and emission for the FNAL DTL.

Figure 3 shows the calculated radiation levels for the SNS DTL, using $\beta = 100$ and $\beta = 200$ as field enhancement factors and takes into account the 60 Hz repetition rate for the 1.167 ms flat top of the rf at SNS as compared to 15 Hz and 0.1 ms respectively for FNAL , yielding a factor of 46.67 on the duty factor. The wall thickness for the SNS DTL is ~7.5 cm and for the FNAL DTL 2 cm.

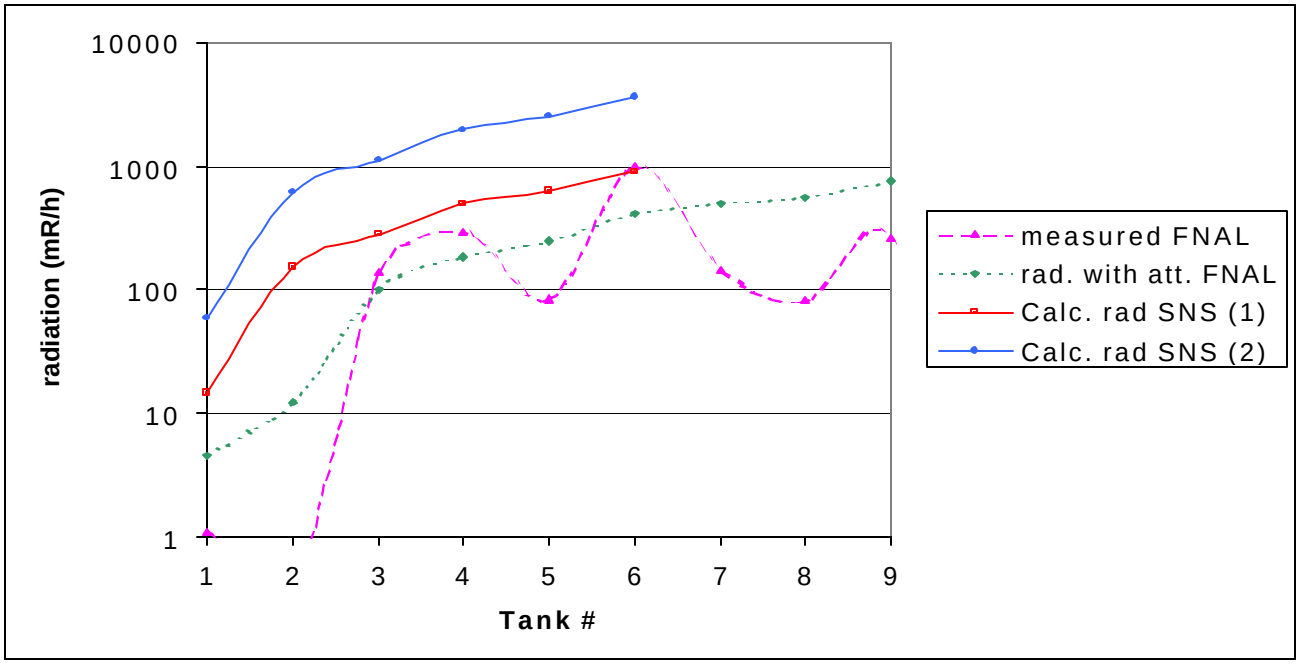

Figure 3: Radiation for the FNAL and SNS DTL. Data for SNS are for $\beta = 100$ (1) and $\beta = 200$ (2).

In order to bring the radiation level around the SNS tanks 1 and 2 below 10 mR/h, one might add lead cladding to these tanks. Tank 1 would need one order of magnitude in attenuation, tank 2 two orders of magnitude. Adding lead cladding of 0.4 cm and 2 cm thickness respectively would suffice [4], assuming the tank structure can bear the weight. Nevertheless, it is advisable to measure the radiation fields at commissioning time, seen the on average factor three difference in measured and calculated radiation for the FNAL DTL.

[1] Roy Cutler, "Possible DTL Radiation levels",SSCL Memo, Sep. 9, 1992
[2] Tom Wangler, "RF Linear Accelerators", 1998, pp.155-158
[3] Tom Wangler, "RF Linear Accelerators", 1998, pp.159
[4] NCRP, "Radiation Protection Guidelines for 0.1-100 MeV Particle Accelerator Facilities",1977, pp.106